1 November 1971

*Materiel Test Procedure 8-1-001
Dugway Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
BACKGROUND DOCUMENT

TESTING CHEMICAL, BIOLOGICAL AND RADIOLOGICAL EQUIPMENT

1. INTRODUCTION

CBR equipment items are developed to provide the Armed Forces with the capability of: (1) retaliation in kind when chemical agents are employed by enemy forces, and (2) protection, including detection and surveillance, against the lethal or incapacitating effects of CBR agents, thereby maintaining continuity of operations in a toxic environment.

The sequence of events leading to the type classification and procurement of CBR items follows the pattern established for other items which enter the supply system. It progresses from the establishment of a military requirement, through the determination of feasibility, to Materiel Needs (MN) which serves as a basis for the development of equipment, and research and development programming actions. Throughout this development cycle, the item is subjected to constant testing and evaluation.

Engineering Tests are, by definition, tests conducted by or under the supervision of a separate test agency, not a part of the developing agency concerned, using an engineering approach where the objective of the test is to determine the technical performance and safety characteristics of an item or system and its associated tools and test equipment as described in the MN and as indicated by the particular design. This determination includes the measurement of the inherent structural, electrical, or other physical properties and may utilize data previously generated in conduct of Engineer Design Tests. The engineering test is characterized by controlled conditions and the elimination of human errors in judgment, so far as possible, through the utilization of environmental chambers; physical measurement techniques; controlled laboratory, ship and field trials; statistical methodology; and the use of personnel trained in the engineering or scientific fields. The engineering test provides data for use in further development and for determination of the technical and maintenance suitability of the item or system for service test.

Engineering tests, properly conducted, should provide sufficient information to permit determination of:

a. The degree to which the technical performance of the item meets the requirements of the MN or other materiel requirements documentation.

b. The relative safety of the item in the hands of troops.

c. Suitability of the item for the conduct of a Service Test.

Commodity engineering tests are specially designed to check

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the functioning of a specific item of equipment. As part of such testing, commodity items are subjected to certain selected common tests, (as applicable). These are:

a. Receipt Inspection
b. Rough Handling and Surface Transport
c. Air Drop Capability of Materiel
d. Radiography
e. Decontamination
f. Leak Testing of Protective Equipment
g. Leak Testing of Chemical Agent-Filled Munitions and containers
h. Dissemination Characteristics, Chemical Munitions/ Dissemination Devices
i. Air Portability and Air Drop Service Testing

Expanded Service tests (EST) are conducted with troops representative of those who will operate the equipment. The materiel under test is operated under simulated tactical conditions or conditions similar to those expected in the area of intended operational use. The purpose of the EST is to determine whether or not the materiel is suitable for its intended use by: (1) measuring to what degree the materiel meets performance standards specified in the requirements document; (2) testing and evaluating the training package and maintenance test package; and (3) testing a small tactical unit equipped with the materiel by means of a controlled field exercise to provide data on the overall item/unit effectiveness or military worth as input to the evaluation process.Consideration is given to verifying doctrine, organization and tactics, basis of issue, logistical support and training requirements. The EST is characterized by qualitative observations and judgment of selected military personnel having a background of field experience with a type of materiel comparable to that undergoing test, with instrumentation limited to those measurements of characteristics of major operational significance.

Environmental Tests are performed to determine if an item performs effectively in the environments of its intended use. Environmental Tests form an integral part of testing, at all phases. Testing in simulated climatic extremes is normally used to the maximum extent. Testing in extreme natural climatic environments is used to substantiate or supplement data obtained from simulated tests. Since testing in natural locations of extreme climate is costly in terms of manpower, money, materiel, and time, requirements for testing of each item in natural environments must be carefully determined before submitting the item for such testing. Such predetermination of necessary testing in natural environments is vitally important and should not be omitted in test design.

Data derived from previous controlled tests in simulated environments are used to the utmost. These data determine the necessity and extent of natural environments testing, and whether the materiel meets essential requirements of performance in extreme field conditions.

No item is authorized for testing in extreme natural environments until its development is determined to have reached a particular state of refinement. Based on all available data from simulated environmental tests, reasonable assurance must be made that the equipment will function satisfactorily in the area of intended use prior to sending it to the natural environment for test.

2. CATEGORIES OF CBR EQUIPMENT

CBR items of equipment can be grouped together according to the principal functions they are to perform.

a. Auxiliary Equipment - These are items which are used in shipment, filling, field impregnation of clothing, etc. They are generally used in conjunction with other items.

b. Collective Protection Systems - These systems are designed to provide and maintain filtered air under positive pressure at a level which precludes the infiltration of hazardous levels of toxic agents. These systems are adaptable for use with storage tanks, field medical facilities, and other shelters such as command posts, communications centers, portable pressurized shelters, and certain vehicles and vans. Included in this category are:

1) Collective Protection Systems, Vehicles and Vans
2) Collective Protection Systems, Field Shelters
3) Collective Protection Systems, Fixed Installations

c. Decontamination Equipment - These items of equipment are designed to facilitate the process of making any person, object, or area safe by absorbing, destroying, neutralizing, making harmless, or removing chemical or biological agents. Included in this category are:

1) Decontaminating Apparatus, Portable
2) Decontaminating Apparatus, Power Driven, Vehicular or Skid Mounted
3) Decontamination Kit, Individual, Field

d. Detection and Surveillance Equipment - This equipment is intended to provide friendly troops with sufficient notice of a CB agent attack to enable them to take adequate protective measures. Also included in this category are items with the capability of sampling and identifying chemical agents, detection of personnel, or marking and tracking of personnel. This classification of equipment includes:

1) Alarms, Biological
2) Alarms, Chemical
3) Chemical Agent Detector Kit
4) Sampling and Analyzing Kit
5) Personnel Detector
6) Marking and Identification System
7) Field Laboratories

e. Dissemination Devices - This equipment is intended for use in distributing relatively large quantities of chemical agents or smoke over a large area. Such items are designed to disseminate bulk, micro-pulverized powders, liquid agents, or slurries. These items include the following:

1) Disperser, Riot Control Agent, Portable
2) Disperser, Riot Control Agent, Vehicular or Helicopter-Mounted
3) Screening Smoke Dissemination Sub-System for Army Aircraft
4) Tanks, Spray, Antipersonnel, Anticrop and Defoliant Chemical Agent
5) Generators, Smoke, Mechanical
6) Flame Throwers

f. Munitions - These items of equipment are designed for the delivery of chemical agents, smoke, or incendiaries to selected targets, and include:

1) Bomblets, Chemical
2) Target and Area Smoke Marking Munition Sub-System for Army Aircraft
3) Generators, Smoke, Pot
4) Grenades, Hand, or Weapon Launched, Smoke/Incendiary
5) Grenades, Hand, or Weapon Launched, Smoke, Colored Marking
6) Grenades, Hand, Riot Control
7) Mines, Land, Chemical or Flame
8) Multiple Sub-Munitions Systems, Riot Control
9) Projectiles and Cartridges, Chemical, Smoke/incendiary
10) Warheads, Guided Missile, Chemical Agent
11) Warheads, Rocket, Chemical Agent

g. Individual Protective Equipment - These items of equipment are designed to protect the individual from the effects of CB agents by: (1) preventing the entry of such agents into the respiratory system, (2) decreasing the cutaneous and precutaneous hazards. Included in this category are:

1) Boots, Protective
2) Breathing Apparatus, Self-contained Air/Oxygen Supply
3) Ensemble, Protective, Supplied Air
4) Gloves, Protective
5) Hoods, Protective
6) Liners, Protective
7) Masks, Protective
8) Overgarment, Protective, Disposable
9) Respirators
10) Casualty Bags

3. PECULIARITIES AND POSSIBLE PROBLEM AREAS ASSOCIATED WITH TESTING WITHIN THE VARIOUS CATEGORIES OF CBR EQUIPMENT

a. General - CBR equipment is unique in that the functions of the majority of items are associated in some way with chemical or biological agents. CBR equipment either protects against agents, detects and identifies them, neutralizes or decontaminates them, or disseminates chemical agents. There is a group, also in the CBR equipment category, which is identified with the conventional weapons classification. This group includes items involving flame, smoke and incendiary agents, and agents of the riot control type.

b. Test Site - The test site must be selected with care. It must be sufficiently isolated to prevent inadvertent exposure to chemical agents, and be of adequate dimensions to allow proper evaluation of the dispersion characteristics if a munition or dissemination device is being tested. The type of terrain, vegetation, and prevailing atmospheric conditions are factors to be considered in test site selection.

c. Special Considerations (Agents and Agent Dissemination) - Instrumentation is an essential part of testing. Because chemical agents, once released, are wholly dependent upon the prevailing atmospheric conditions and those surface effects produced by terrain features and vegetation in the target area, adequate measuring instruments to record temperature, temperature gradient, wind speed and direction, atmospheric pressure, and relative humidity must be employed. Once an agent is released, it is imperative to determine the dosage at various locations in the horizontal and, if possible, vertical plane. The proper selection of sampling devices to collect these agents is of utmost importance.

In the testing of chemical agents to be delivered by munition or dissemination device, the projection and evaluation of effects on humans is hampered by the lack of combat-casualty information. Chemical agents have not been employed to any extent since World War I. There are data available on mustard casualties from that war, but casualty information concerning nerve agents is incomplete.

d. Special Considerations (Protective Equipment) - In testing individual protective equipment, human engineering aspects are of paramount concern. Testing protective masks, for instance, involves not only determining if they will deliver CB agent-free to the wearer, but also evaluating the following factors: (1) comfort of fit while wearing, (2) ease of breathing (inhalation and exhalation), (3) visibility (with and without optical inserts), (4) interference with other equipment carried or used, (5) interference with normal duties, (6) ease of donning, (7) comfort during exposure to high temperature and humidity, (8) the nosecup fit, (9) adequacy of speech transmission, and (10) mask stability. Data pertaining to the technical characteristics are gathered as a result of laboratory testing; human factors aspects are best arrived at by the interrogation of test subjects who participated in a series of wearing tests.

Protective clothing must also be subjected to a human factors evaluation. It must be comfortable to wear, not cause skin irritation, produce a minimum of heat fatigue, and be easily put on and removed. In testing protective clothing, a human factors engineer should be consulted to devise a suitable method of questioning wearers concerning these aspects.

Collective protection provides CB agent-free air to a number of individuals who would otherwise be hampered by wearing a protective mask. The unit is connected to a shelter, a vehicle, a van, or a fixed installation and causes a positive pressure to be built up therein, which precludes infiltration of CB agents. It must be rugged, dependable, and compatible with the equipment it serves.

e. Special Considerations (Detection and Surveillance Equipment) - The value of this type of CBR equipment lies in its sensitivity, quick response time, and low false alarm rate (alarms). In testing, particular attention must be paid to these characteristics in order to derive valid data. Human factors are involved: (1) in testing the audibility or visibility of an alarm signal, (2) in determining if the operator can successfully manipulate a detector kit and properly recognize the results.

f. Special Considerations (Decontamination Equipment) - Caution must be exercised in the use of decontamination agents to avoid the irritation to eyes, skin, and respiratory track which some chemicals produce. The reaction of some decontamination agents with certain chemical agents resulting in toxic fumes or flashing should be avoided or minimized.

4. MAJOR FACTORS THAT INFLUENCE DEVELOPMENT OF SPECIFIC TEST PLANS

4.1 INTRODUCTION

a. A test plan is a statement outlining the approach, test criteria, test objectives, and methods along with the scope and length of the test required including those specific subtests necessary to determine the degree to which a test item meets the prescribed MN requirements. A plan of test is complete in itself and capable of standing alone.

b. Upon receipt of a test directive, a test plan is prepared based upon a study of the criteria established, a literature search, discussions with experienced individuals, and numerous planning conferences. At the detailed test plan stage, tests are specifically designed to ensure that reliability requirements can be evaluated on the basis of resulting data. Concurrently, an operations plan is formulated, outlining precise safety, operational and logistical aspects of the test. Safety aspects are preferably set forth as an annex to the operational plan.

c. Basically, a test plan covers the objective, methods of testing to be employed, and the information and data required.

4.2 OVERALL STATE OF THE ART OF ANALYSIS AND EVALUATION MEANS

Successful procedures for testing CBR equipment are well documented in the literature. Experience over the years at Deseret Test Center, Utah, and other test facilities has resulted in a refinement of test methods to achieve the ultimate in results. Military Standards have been written which adequately describe testing methods in the field of environmental testing, and fuze and fuze component testing. Other testing documents outline procedures for leak testing, agent resistance testing, fabric characteristics testing, etc., to which certain items of equipment must be subjected. Simulants are available for use in lieu of certain live agents to evaluate chemical dissemination characteristics, detection capabilities, etc, when the toxicity of the agent is not being evaluated. With the testing techniques and means now available and the qualified personnel present to apply these techniques, testing of CBR equipment presents less of a problem than was formerly the case. The increased capability achieved in operations research, statistical analysis, and computerization has resulted in the attainment of greater accuracy in relating the large amount of test data collected to meaningful conclusions. As more experience is gained in these fields, results of tests shall become even more refined and meaningful.

4.3 INSTRUMENTATION REQUIREMENTS AND AVAILABILITY

a. A very essential step in testing CBR materiel is the acquisition of data from the field concerning chemical agents disseminated and CB agents protected against, detected, or neutralized. These data are collected in such a way as to permit analysis necessary to the formation of valid conclusions. To do this, many sampling devices are available. This equipment is being improved continually to achieve more efficient operations. In the selection of sampling devices, the composition of the agent to be tested, the prevailing weather conditions, the type of vacuum source employed to draw the agent into the sampler, the rate of sampling required to produce desired results, and other factors must be considered.

b. Examples of instrumentation available and a brief description of their application follow.

1) Gas bubble (may be aspirated sequentially) - collection of gaseous samples
2) Sequential sampler - sequential sampling of agent vapor at predetermined sampling intervals
3) Printflex cards - collection of chemical agents disseminated in droplet form
4) Biological impinger and pre-impinger - sampling of viable biological particulates
5) Biological membrane filter - collection of fluorescent particles or tracer material; may be used to collect bacteria in some instances

6) Gelman membrane filters - collection of chemical agent dispersed in the form of finely divided particles
7) B/C sampler - collection of sequential and/or total dosage samples of vapor or particulate biological or chemical agent or agent simulants at given time intervals
8) Snoot sampler - sampling of particulates
9) Wagner sampler and pre-impinger - sampling biological agents
10) Wagner sampler - sampling of liquid and dry aerosols in the size range of one to five microns
11) Anderson or cascade sieve sampler - sampling biological aerosols. The device consists of variably perferated discs, containing petri dishes supplied with a solid culture medium, which varies according to agent sampled.
12) Cascade impactor - quantitative and qualitative sampling of windborne or stationary clouds of droplets or dust in the size range of 0.5 micron to 200 microns.
13) Rotorod sampler - rotates at a speed of 2400 rpm, sampling 40 liters of air per minute; used in collection of fluorescent particles and BG (Bacillus subtilis var niger) spores.
14) Reyniers sampler - time-concentration sampling of biological simulants or tracer matererials.

c. In addition to the specialized sampling instrumentation required, the testing of CBR materiel (depending on the item tested) also involves the use of other types of instrumentation. Examples of this equipment are:

1) Meteorological data collection equipment. Theodolite and pibal equipment enable the plotting of wind speed and direction at various atmospheric levels. The Rawin Set, a radio direction finder, tracks a balloon-borne radiosonde. Signals from the radiosonde are converted to values of temperature, humidity, pressure, and winds aloft. Micrometeorological telemetering equipment is used to collect and record meteorological data. Meteorological equipment is adaptable to computerizing.
2) Photo-cinetheodolite. This instrument utilizes film to record the path or moving targets. This documentation include a record of azimuth and elevation angle of the target relative to the cinetheodolite position. Photo-cinetheodolites are valuable in testing chemical warheads, rockets, projectiles, and items tested for air drop capability.

3) Photographic equipment. It is of utmost importance in testing CBR materiel that a record be made of the test sequence. To attain this documentation, motion pictures and still photographs are employed. Motion picture cameras are available which operate at frequencies from 10 pictures per second to 20,000 pictures per second. In addition, certain cameras are equipped with control boxes which synchronize the camera operation with the event to be photographed.

4) Miscellaneous equipment. In the testing of CBR materiel, recording voltmeters and ammeters, thermocouples for continuous monitoring and recording of temperature, recording differential pressure transducers, accelerometers, and other standard laboratory measuring instruments are employed.

d. Instrumentation for use in testing is readily available and requires only the selection of the right type for the task to be performed. A note of caution to the test officer concerns the calibration of instruments used. All test and measuring instrumentation utilized for data acquisition, repair, and maintenance will be calibrated and certified prior to use.

4.4 SAFETY CONSIDERATIONS

a. No other aspect of testing has a higher precedence than safety. For that reason, the test officer must be thoroughly acquainted with certain safety requirements.

1) He shall ensure that the Safety Statement pertaining to the item undergoing test has been received and is understood. The Safety Statement includes information pertaining to operational limitations and specific hazards peculiar to the system or components to be tested.

2) Procedures followed shall ensure performance in the safest manner consistent with accomplishing the mission. The cardinal principle is to limit exposure of a minimum of personnel, for a minimum time, to a minimum amount of hazardous material consistent with safe and efficient operations. Plans shall include safety procedures, precautions, protection and emergency procedures (including evacuation and medical), as necessary. Technical information on the hazards and safety characteristics of the test item as provided by the Safety Statement and other pertinent information shall be included. Such information shall include evaluation of potential hazards, analysis of risks, limitations, and precautions including special

test equipment and techniques that should be incorporated in test plans and procedures.

3) A specific individual shall be charged with responsibility for safety. He shall know the construction and operation of the test item and its critical components, shall have full knowledge of the hazards and safety aspects of the test, and shall review test procedures for evaluation of hazards and recommend control measures.
4) All personnel who participate in or observe the tests shall be briefed on the hazards involved, the precautions required, and the proper procedures to follow.
5) Throughout each phase of the test, safety information and data shall be gathered as input to the Safety Release Recommendation required by U. S. Army Test and Evaluation Command (TECOM).

4.5 STATISTICAL AND DATA REDUCTION TECHNIQUES

a. General considerations in planning - It is advantageous for the test plan author and test officer to consult with the statistical analyst prior to the conduct of the test to determine the experimental pattern. The proper pattern for the experiment will aid in control of bias and in measurement of precision, will simplify the requisite calculations of the analysis, and will permit clear estimation of the effects of the factors. Three statistical tools aid in the development of the proper pattern for an experiment. These are discussed in the following paragraphs.

1) An important class of experimental patterns is characterized by planned grouping. The tool of planned grouping can be used to take advantage of naturally homogeneous groupings in materials, machines, time, etc., and so to take account of "background" variables which are not directly factors in the experiment.
2) Randomization is an arrangement of tests, samples, and other factors so as to simulate a chance distribution, reduce interference by irrelevant variables, and yield unbiased statistical data. It is a useful statistical tool which ensures valid estimates of experimental error and makes possible the application of statistical tests of significance and the construction of confidence intervals.
3) Replication is the repetition of an experiment or procedure at the same time and place. Where a measure of precision must be obtained from the experiment, replication provides this measure. In addition to providing this measure of precision, replication provides an opportunity for the effects of uncontrolled factors to balance out, and thus, aids randomization as a bias-decreasing tool.

b. Measurement of data - Measurements cannot be made with complete accuracy or precision. The terms "accuracy" and "precision" denote different ideas which are inherent in the measurement method. Accuracy of a measurement method refers to the ability of the method to provide a reading which conforms to the true value, whereas precision of a measurement method refers to the ability of the method to provide repeated readings which to a degree are in sharp agreement with each other regardless of whether they represent the true value. If a magnitude is to be determined with accuracy to a required number of digits, it is necessary that the test method and equipment have precision of this order. That is, precision is a prerequisite to accuracy, but precision does not guarantee accuracy. In general, the test objective will determine the requirements for accuracy and precision, and these in turn will determine the test methods and equipment to be used.

The measured value of a characteristic may be represented by the following relationship:

MEASURED VALUE = TRUE VALUE + ERROR VALUE

A review of the subject of error sources is an important step in understanding the error value and finding ways of reducing it, and as a means of estimating the validity of the final report.

Errors may originate in a variety of ways and may be grouped under the following three categories:

1) Gross errors
2) Systematic errors
3) Random errors

Gross errors include mistakes made in the reading and recording of data. The responsibility usually lies with the test personnel for slips such as the gross misreading of a scale, or the transposition of figures in recording the result. Errors of this type may be of any amount and are not subject to mathematical treatment.

Two things can be done to avoid such difficulties: the first is to exercise care in reading and recording the data; the second is to make two or more determinations of the desired quantity, preferably at different reading points to avoid re-reading with the same error. Then, if the readings show disagreement by an unreasonably large amount, the situation can be investigated and the bad reading eliminated.

Systematic errors may be further subdivided into the following:

1) Instrumental errors
2) Environmental errors
3) Observational errors

Instrumental errors are those due to shortcomings of the instrument. All instruments and standards posses inaccuracies of some amount. As supplied by the maker, there is always a tolerance allowance in the calibration, and additional inaccuracies may develop with use and age. As an example, suppose that measurements of length are made with a yardstick after a small amount has been cut from the zero end; all measurements made with this yardstick will be systematically in error by a constant amount. Or, as another example, the ratio arms of a Wheatsone bridge may have an actual ratio different from the marked value. This causes a systematic instrumental error of proportional amount for all measurements using these arms. An indicating instrument, such as a voltmeter, has scale errors; these errors are generally different at different parts of the scale, and do not partake of either the constant or proportional type, and must be expressed by a correction curve.

It is important to recognize the possibility of such errors when making precision measurements, for it is often possible to eliminate them, or at least to reduce them greatly by methods such as the following:

1) Careful planning of procedure.
2) Determination of instrumental errors and application of correction factors.
3) Careful recalibration of the instrument.

Another source of instrumental systematic error is misuse, or loading effects, of the instruments. This shortcoming in measurements may be traced all too often to the test personnel, rather than to the equipment. A good instrument, used in an unintelligent way, may give poor results. This may come from such things as failure to make a needed zero adjustment in a bridge or meter, poor initial adjustment, the use of connecting leads of too high resistance for the measurement being made, and many other possibilities. Also, careless or uninformed use of an instrument may do permanent damage as a result of overloading and overheating the instrument; in this case the value of the instrument, and of future as well as present readings, is depreciated until the trouble is detected and repairs are made. Indicating instruments always change conditions to some extent when connected into a complete circuit; sometimes the effect is negligibly small. Sometimes the effect, though not negligible, can be corrected by computation. At other times, the presence of the instrument produces so great a change in circuit conditions that operating conditions in the circuit are altered radically. The test personnel must take into consideration the effect that the measuring equipment has on the circuit, and plan the measurements accordingly.

Environmental errors are also called "errors due to external conditions," that is, conditions external to the measuring device. This includes any condition in the region surrounding the test area that has an effect on the measurements. One common source of variation comes from temperature changes of the equipment. Some instruments may be affected by humidity, barometric pressure, the earth's magnetic field, gravity, and magnetic fields, and others.

There are several kinds of action that can be taken to eliminate, or at least to reduce, the undesirable disturbances:

1) Arranging to keep conditions as nearly constant as possible, for example, enclosing the equipment in a temperature controlled cabinet.
2) Use of equipment largely immune to such effects.
3) Computed corrections, in some cases.

It should be noted that any of these methods can be considered, at best, to neutralize the major part, but not all, of the error. Correction is accomplished to a "first-order" of approximation, but leaves "second-order" or "random" errors.

Observational errors or "errors of the observer" is a name that recognizes that there exists a "personnel equation" for the observer, so that people using the same equipment for duplicate sets of measurements do not necessarily produce duplicate results. One observer may tend characteristically to read a meter higher (or lower) than the correct value, possibly because of his reading angle and failure to eliminate parallax. Important readings which may be subject to this type of error should be shared by two or more personnel to minimize the possibility of constant bias.

After attention has been given to all known sources of error discussed above, it has been found repeatedly that the data from tests show variations from reading to reading. There is no doubt a reason, or rather a set of reasons, for these variations, but these are not obvious or easily determinable. These errors may be regarded as the residue of error when all known systematic effects have been taken into account and are known as random errors. Random errors are probably caused by a large number of small effects, each one variable. If the presence of a large number of small effects is assumed (each of which may give either a plus or minus effect in a completely random manner), the condition of scatter around a central value is obtained. This condition is generally observed in test data. The supposition of randomness facilitates application of various mathematical techniques in attempts to isolate and make inferences about error sources and effects.

The function of statistics is to separate, as far as possible, the truth from error by narrowing and defining the region of doubt. Note however, that statistical study is concerned primarily with the precision of measurement. It cannot reveal anything that is not implicit in the data, and cannot remove systematic errors from a set of data. Accuracy is a matter of test methodology and equipment. The added precision afforded by statistical study may permit detection of a discrepancy, which is a necessary step.

c. Statistical considerations - Statistics, as defined, is a branch of mathematics dealing with the collection, analysis, interpretation, and presentation of masses of numerical data.

1) If an entire population (every one of a certain item made) could be examined, the task would be merely to describe that population using whatever numbers, figures, or charts necessary. Since this is inconvenient, and in most cases impossible, a sample is taken (assumed to represent the characteristics of the entire population). From observations of this sample, generalizations about characteristics of the population are made. These generalizations are termed statistical inferences.
2) In order to make valid generalizations about characteristics of the entire population from samples, samples must be obtained by a sampling scheme which ensures that relevant characteristics of the population sampled bear a known relation to the corresponding characteristics of the population of all possible samples. To accomplish this, random selection (each possible sample having a fixed and determinate possibility of selection) is used.

NOTE: Tables of random numbers are published in the literature on statistics.

d. Analysis and presentation of data - A large amount of data is collected as a result of testing. Because these data have meaning only in comparison with similar data, the quantitative measures obtained from a test must be reduced to values having units which are acceptable as a basis for comparison. In reducing the data, errors which would affect the accuracy of the results must be identified and compensated for.

When raw data have been reduced to workable numbers, the statistician, using proven mathematical methods at his disposal, arrives at a conclusion. The conclusion may be a percentage confidence level related to a percentage probability that the item tested will perform as specified, or another mathematical means of presenting the data required. Computers are often used to advantage in arriving at these results.

The final step is the presentation of data. It must involve thought and intelligence in its preparation, and is influenced by the capacity, the ingenuity, and background of the analyst.

The test of good data presentation lies in its usefulness to equipment performance analysts who evaluate the data relative to established criteria and make the decisions regarding acceptability of equipment performance.

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13. ABSTRACT

Provides introductory discussion on testing CBR equipment. Discussion covers categories of CBR equipment and possible problem areas peculiar to CBR equipment testing. Also deals with factors influencing specific test plans such as instrumentation requirements and availability, safety, statistical and data reduction techniques.

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